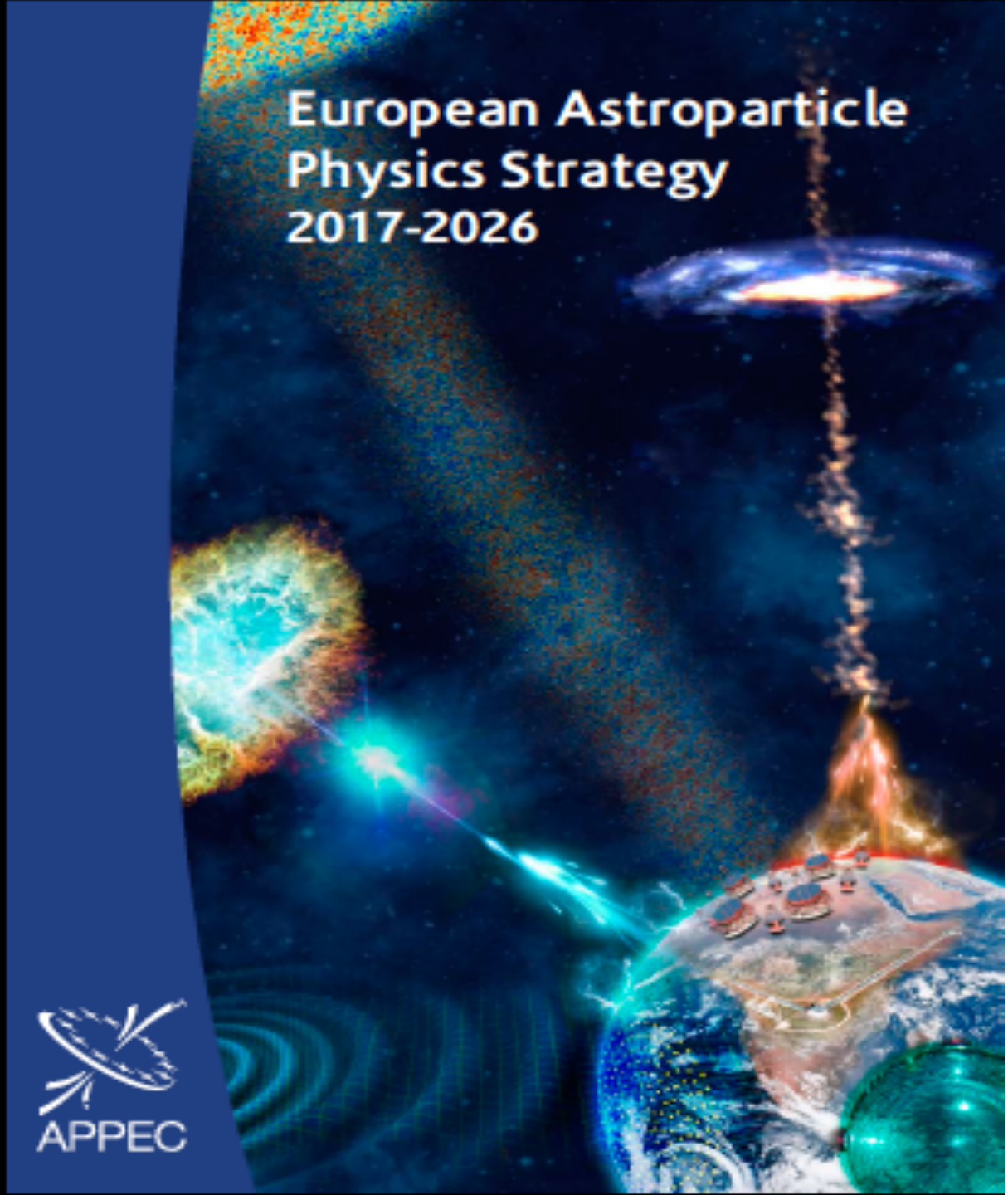


Antonio Masiero

Chair of the APPEC General Assembly

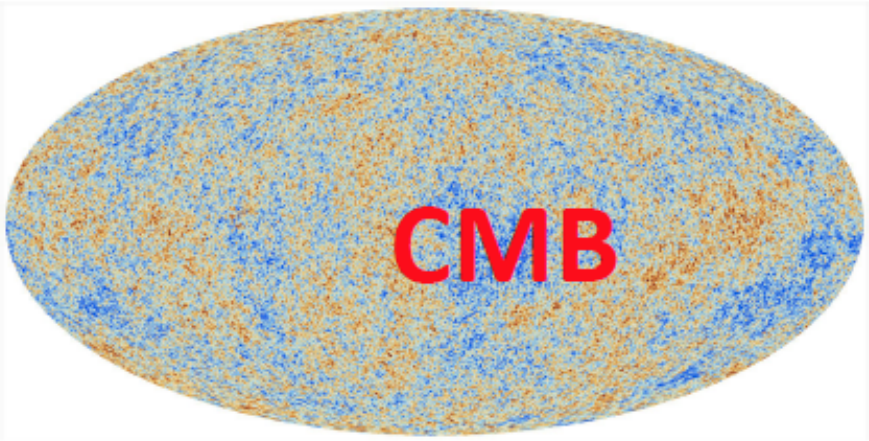
Plenary ECFA, CERN, 15-16 Nov., 2017

- By the end of the 20th century …
  we have a comprehensive, fundamental theory of all observed forces of nature which has been tested and might be valid from the Planck length scale [10^{-33} cm.] to the edge of the universe [10^{+28} cm.]

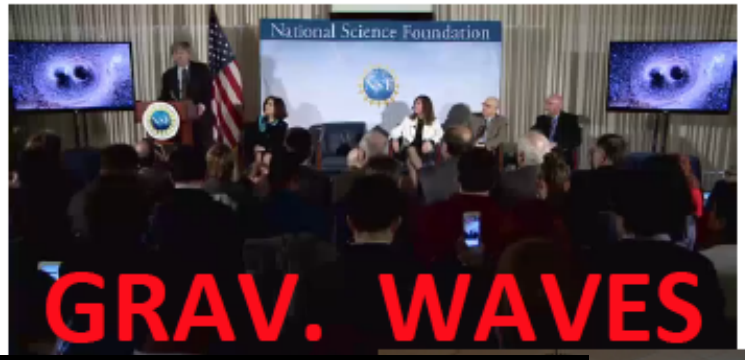
D. Gross 2007

- **PARTICLE STANDARD MODEL**

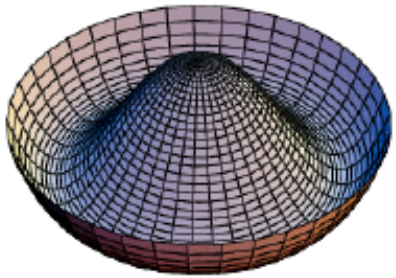
- **COSMOLOGY STANDARD MODEL**

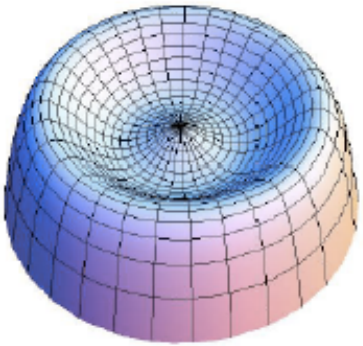


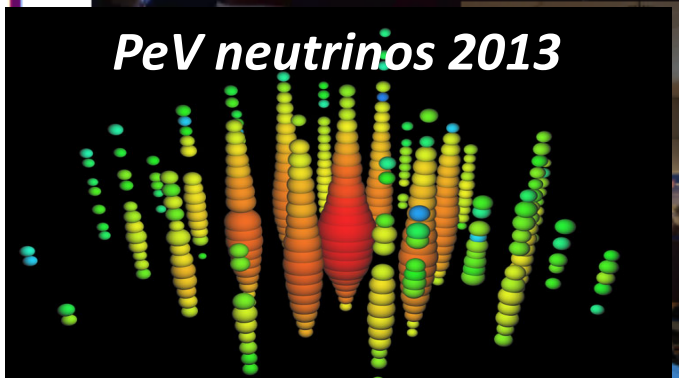
The Higgs boson and the destiny of the Universe

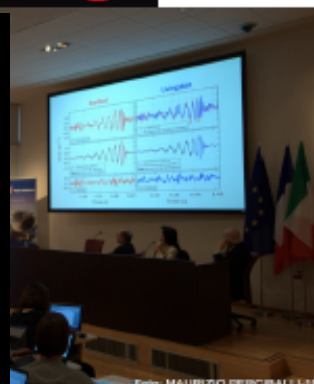


STABILITY ⟷ INSTABILITY

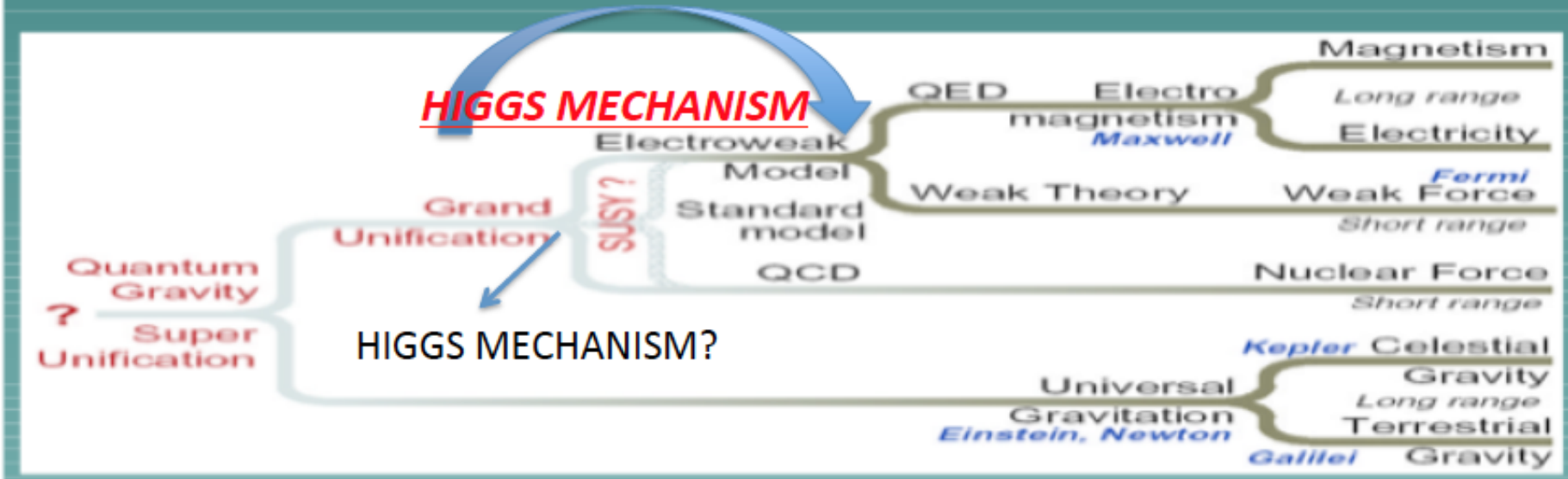






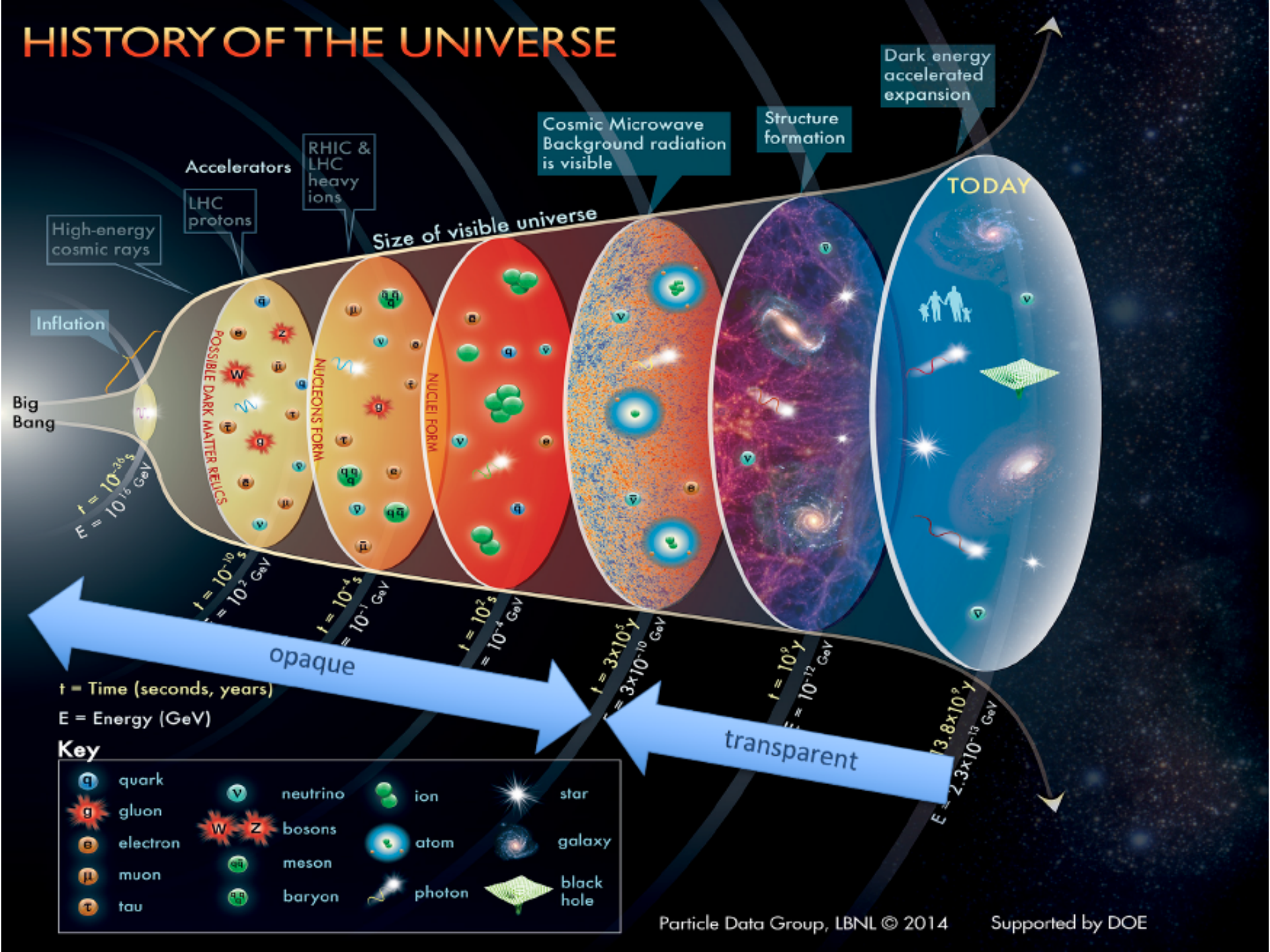


Big Bang			Protoni e neutroni	Protoni e Nuclei leggeri	Atomi →Galassie →Molecole→DNA
Gravità	*Nucleare forte*	*Nucleare debole*			
10^{-43} sec	10^{-32} sec	10^{-10} sec	10^{-4} sec	100 sec	300KY → 15GY
10^{-35} m	10^{-32} m	10^{-18} m	10^{-16} m	10^{-15} m	10^{-10} m
10^{19} GeV	10^{16} GeV	10^{2} GeV	1 GeV	1 Mev	10 eV
???	LHC	LEP			Astronomia→



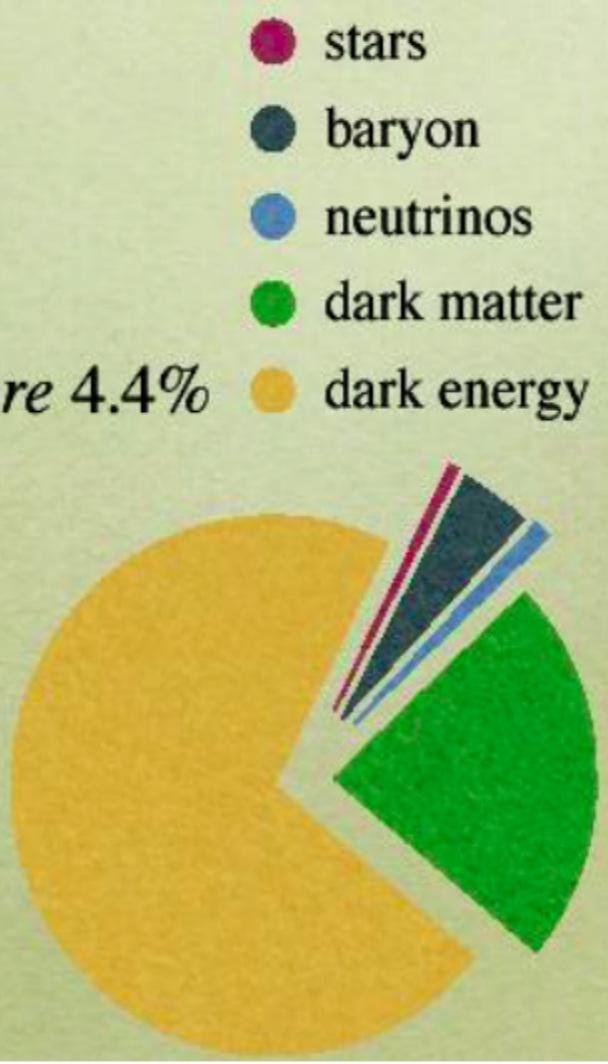
Theories:

STRINGS? RELATIVISTIC/QUANTUM CLASSICAL


HISTORY OF THE UNIVERSE
Dark energy accelerated expansion
Cosmic Microwave Background radiation is visible
Structure formation
Accelerators
RHIC & LHC heavy ions
LHC protons
High-energy cosmic rays
Size of visible universe
TODAY
Inflation
Big Bang
POSSIBLE DARK MATTER RELICS
NUCLEONS FORM
NUCLEI FORM
t = 10^-36 s
E = 10^15 GeV
t = 10^-10 s
E = 10^2 GeV
t = 10^-4 s
E = 10^-1 GeV
t = 10^2 s
E = 10^-4 GeV
t = 3x10^5 y
E = 3x10^-10 GeV
t = 10^9 y
E = 10^-12 GeV
t = 13.8x10^9 y
E = 2.3x10^-13 GeV
opaque
transparent
t = Time (seconds, years)
E = Energy (GeV)
Key
quark
gluon
electron
muon
tau
neutrino
bosons
meson
baryon
ion
atom
photon
star
galaxy
black hole
Particle Data Group, LBNL © 2014
Supported by DOE

***5 numbers, 5 indications of physics beyond the Standard Models of Particle Physics and Cosmology*: NEUTRINO MASSES, DM, DE, ANTIMATTER AND VACUUM ENERGY**

- *Stars and galaxies are only* ~0.5%
- *Neutrinos are* ~0.1–1.5%
- *Rest of ordinary matter*
  (electrons, protons & neutrons) are 4.4%
- *Dark Matter* 23%
- *Dark Energy* 73%
- *Anti-Matter* 0%
- *Higgs Bose-Einstein condensate*
  $\sim 10^{62}\%$??



Courtesy of H. Murayama

A memorable past decade for astroparticle physics...

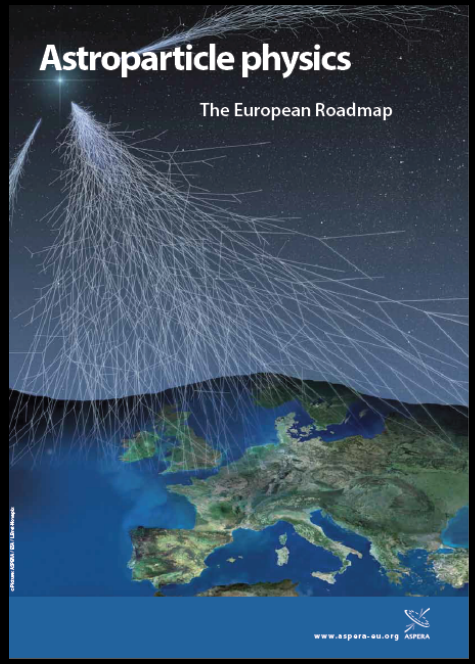
- **Multimessenger astronomy**: 2 new entries, i.e. **2 new cosmic messengers are DISCOVERED**, **HE cosmic neutrinos and gravitational waves**. Important progress in gamma- and charged cosmic ray – astronomy
- Impressive progress in our knowledge of **neutrino properties** through a combined action of **astroparticle physics and cosmology**
- **CMB**: extraordinary achievements by the Planck satellite on our knowledge of CMB temperature fluctuations as well as the CMB polarization modes
- The **dark side of the Universe**: amazing progress in our bounds especially on **WIMP DM**, but **the DM mystery** still remains. In spite of our better knowledge of some **DE** properties, still **its nature remains completely obscure**.

APPEC: *roadmapping*

From the Nature article

2008

2011



Magnificent 7

1. ***HE gammas***
2. ***HE neutrinos***
3. ***HE cosmic rays***
4. ***Gravitational waves***
5. ***Dark matter***
6. ***ν-mass***
7. ***ν-mixing & p-decay***

CMB

Dark Energy

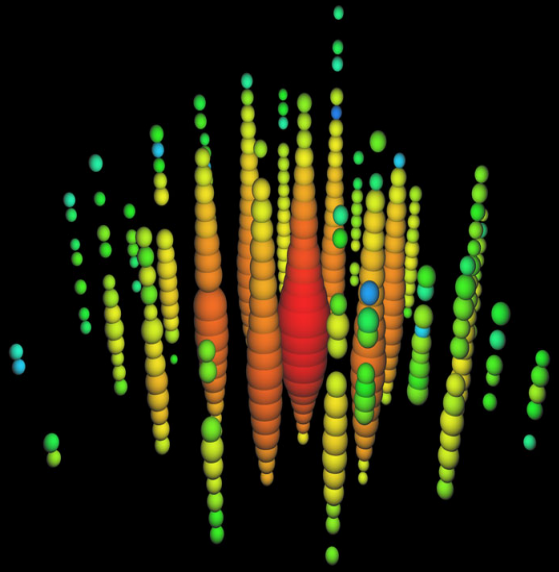
S. Katsanevas

nasty comment at that time:

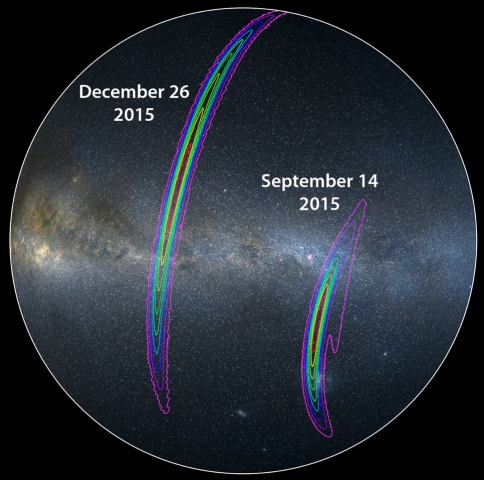
But… at least 4 -5 domains have not been seen as a signal yet

Well, 2 of the domains have detected a signal in the first 3 years

PeV neutrinos 2013



GW1509-2014



The search of point sources for HE cosmic-rays, neutrinos and GW (better pointing) ongoing

APPEC: *roadmapping*

2008

2011

HE universe
- *gammas*
- *neutrinos*
- *cosmic rays*
- *gravitational waves*

Dark universe
- *dark matter*
- *dark energy*

Early universe
- *CMB*

ν-properties
- *mass, mixing, …*

S. Katsanevas

… and a thrilling decade in front of us

- **Multi-Messenger Astronomy** (advent of the cosmic HE neutrino and gravitational waves astronomies, the CTA tremendous leap in gamma astronomy, the new horizon in charged cosmic ray astronomy with the upgrade of AUGER);

- Impressive progress in unveiling (some of) the **neutrino mysteries**: **Dirac vs. Majorana** (1-ton $(\beta\beta)_{0\nu\nu}$ exps.); **ν mass hierarchy** (the race: see fig.); ν CP violation (new long baseline ν exps.); **ν masses** (direct exps., amazing input from cosmology)

… and a thrilling decade in front of us

- **CMB** in the post-Planck (satellite) era → tremendous progress in ground, balloon and space exps.

- Shedding (an impressive amount of) light on the **dark side of the Universe**: **DM** → multi-ton exps. towards the ultimate ν background (attempting to even overcome it); **DE**: remarkable leap in our knowledge of the history of the expansion rate of the Universe and the rate of growth of the cosmic structures through new ground and space exps

Astroparticle Physics in Europe

Many of the next-generation astroparticle physics research infrastructures require **substantial capital investment** and for Europe to remain competitive in this rapidly evolving global research field – on the ground as well as in space – a clear, collective and ***resource aware* strategy is essential**.

As opposed to its progenitors, as a relatively new field European astroparticle physics does **not** profit from a natural and strong inter-governmental organisation like CERN, ESO and ESA to drive the field

Strategic objectives

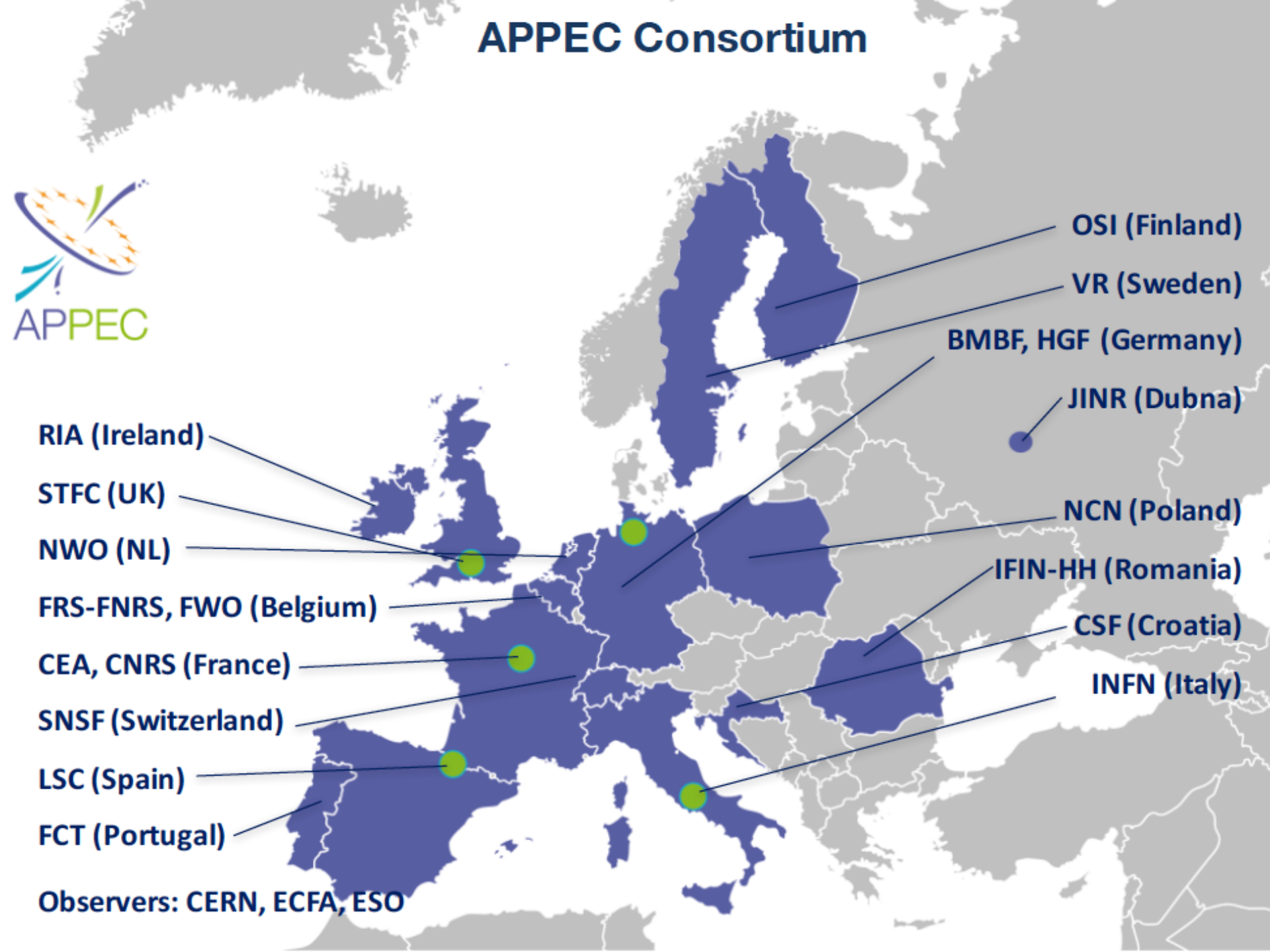
- Coordination of European Astroparticle Physics
- Develop and update long term strategies (roadmap)
- Express collective views on APP in international fora

Implementation objectives

- Coordination between existing/developing national activities
- Convergence of future large scale projects/facilities
- Organisational advice for implementation of large facilities
- Launch common calls funded by a (virtual) common pot

Job de Kleuver

APPEC Consortium



Astroparticle Physics European Consortium

General Assembly

Stavros Katsanevas	2012 – 2014
Frank Linde	2015 – 2016
Antonio Masiero	**2017 –**

Joint Secretariat

Thomas Berghöfer	2012 – 2016
Job de Kleuver	**2017 –**

AstroParticle Physics European Consortium

Scientific Advisory Committee

A. Masiero (chair), Michal Ostrowski, Mauro Mezzetto, Gisela Anton, Laura Baudis, Jocelyn Monroe, Petr Tiniakov, Jo van den Brand, Patrick Sutton, Ramon Miquel, Zito Marco, Andrea Giuliani, Felix Aharonian, Pierre Binétruy, Ignatios Antoniadis, Yifang Wang, Francis Halzen, Hank Sobel, A. Haungs, S.Katsanevas (APPEC)

APPEC *functional centers*

Coordination 2001-2006
ASPERA 2006-2012
Consortium 2012-....

Outreach, Web pages
STFC – Swindon/UK

DESY - Hamburg/D
Management, Computing & Industry

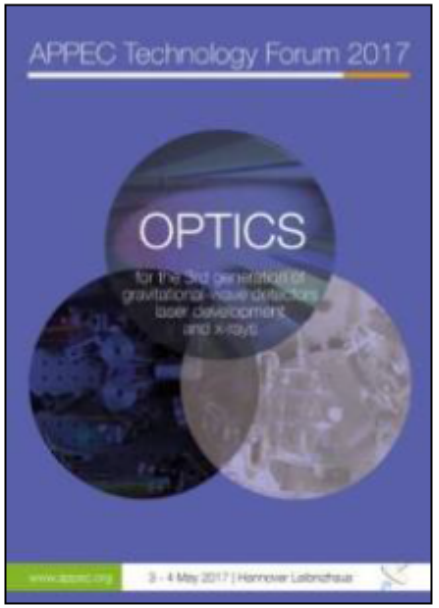
Roadmapping, Common Calls, Interdisciplinary
APC - Paris/F

LNGS - L'Aquila/I

Networking, Theory, Graduate Schools

APPEC initiatives

- Global neutrino meetings
- European CMB coordination
- CTA in its early stage
- APPEC Technology Fora
- Common projects (ET, DARWIN)
- Roadmap



APPEC Roadmaps

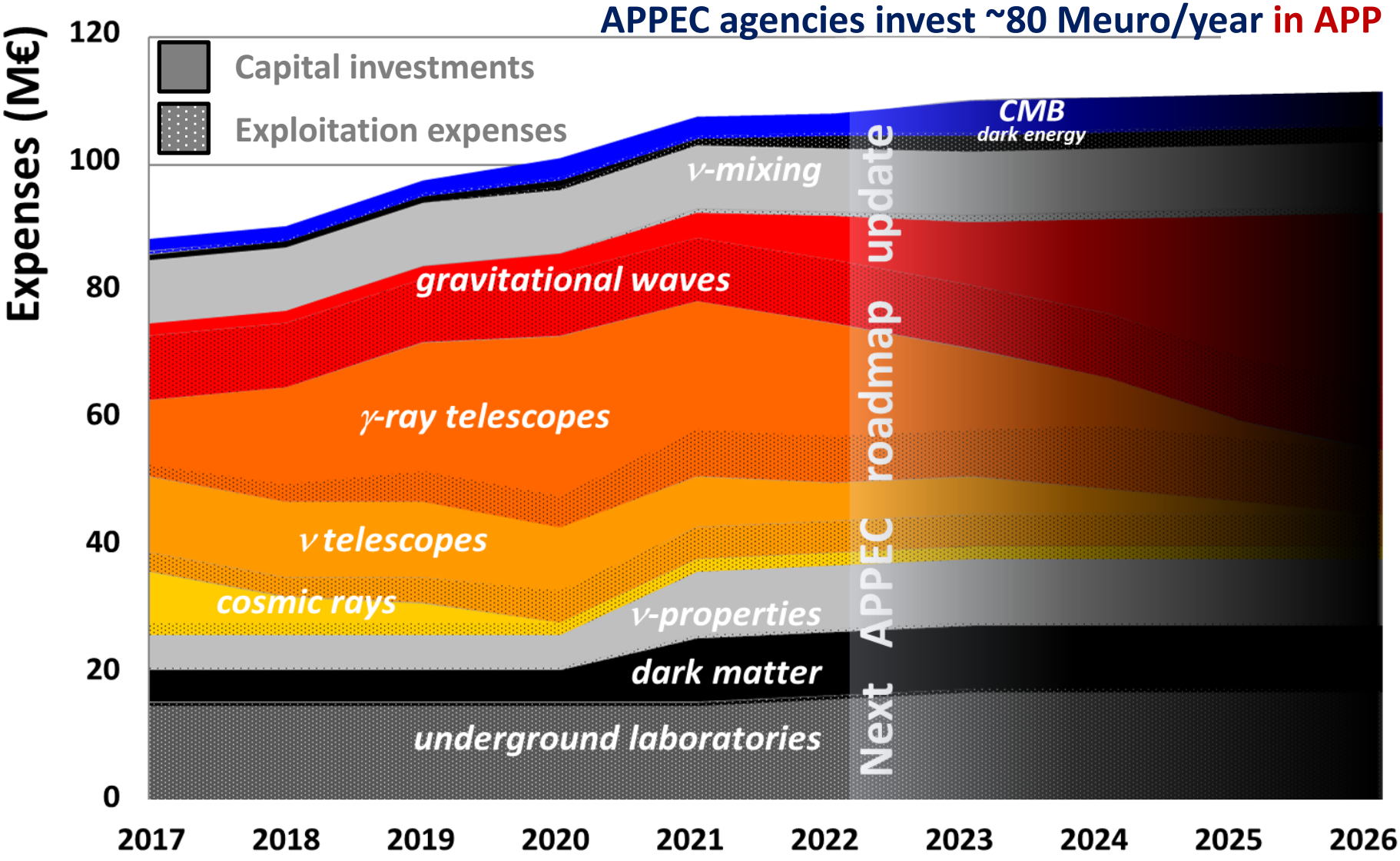
2008

2011

2017

resource aware

APPEC's 2017 strategy …

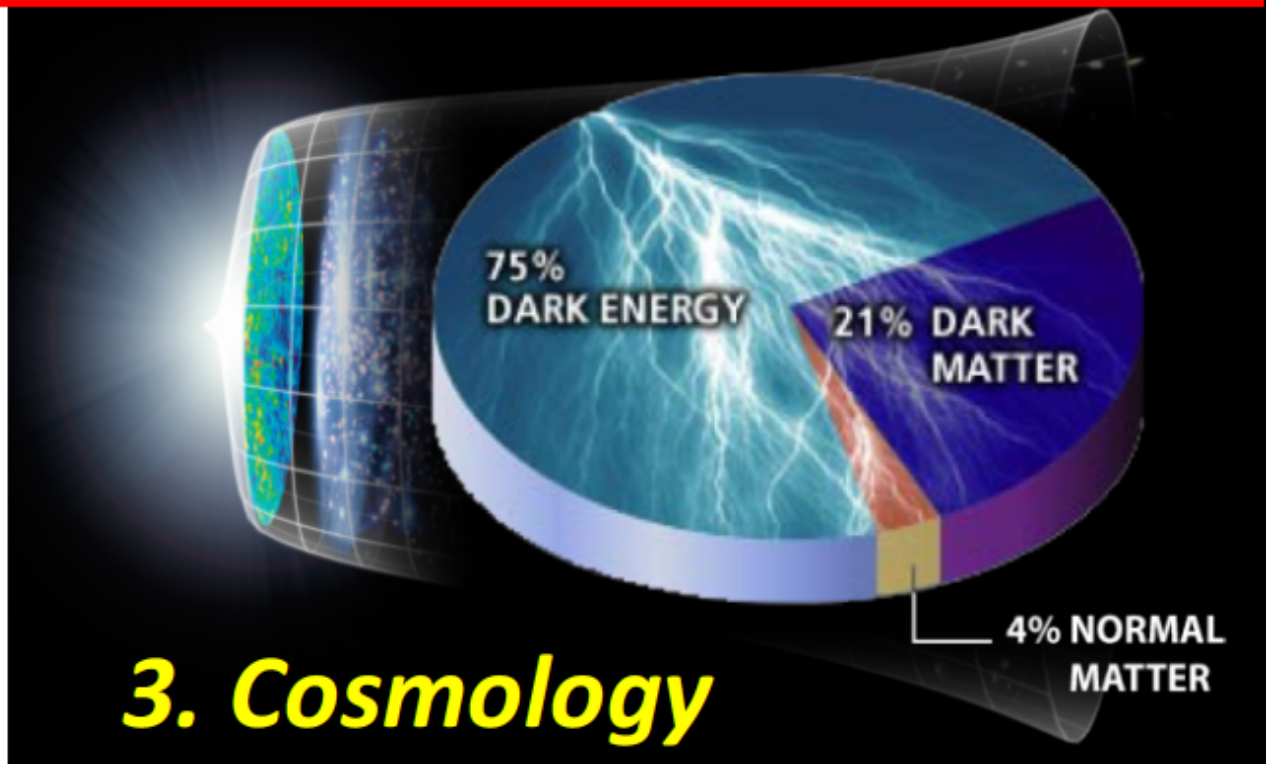


Excludes EU structural/regional, PP, ASTRO, non-EU funding • • •

European roadmaps in fields of science

1. High-energy Universe: multi-messengers

2. Neutrino's



3. Cosmology

ASTROPARTICLE PHYSICS

APPEC

ASTRONOMY

dark energy

gravitational waves

CMB

HE neutrinos

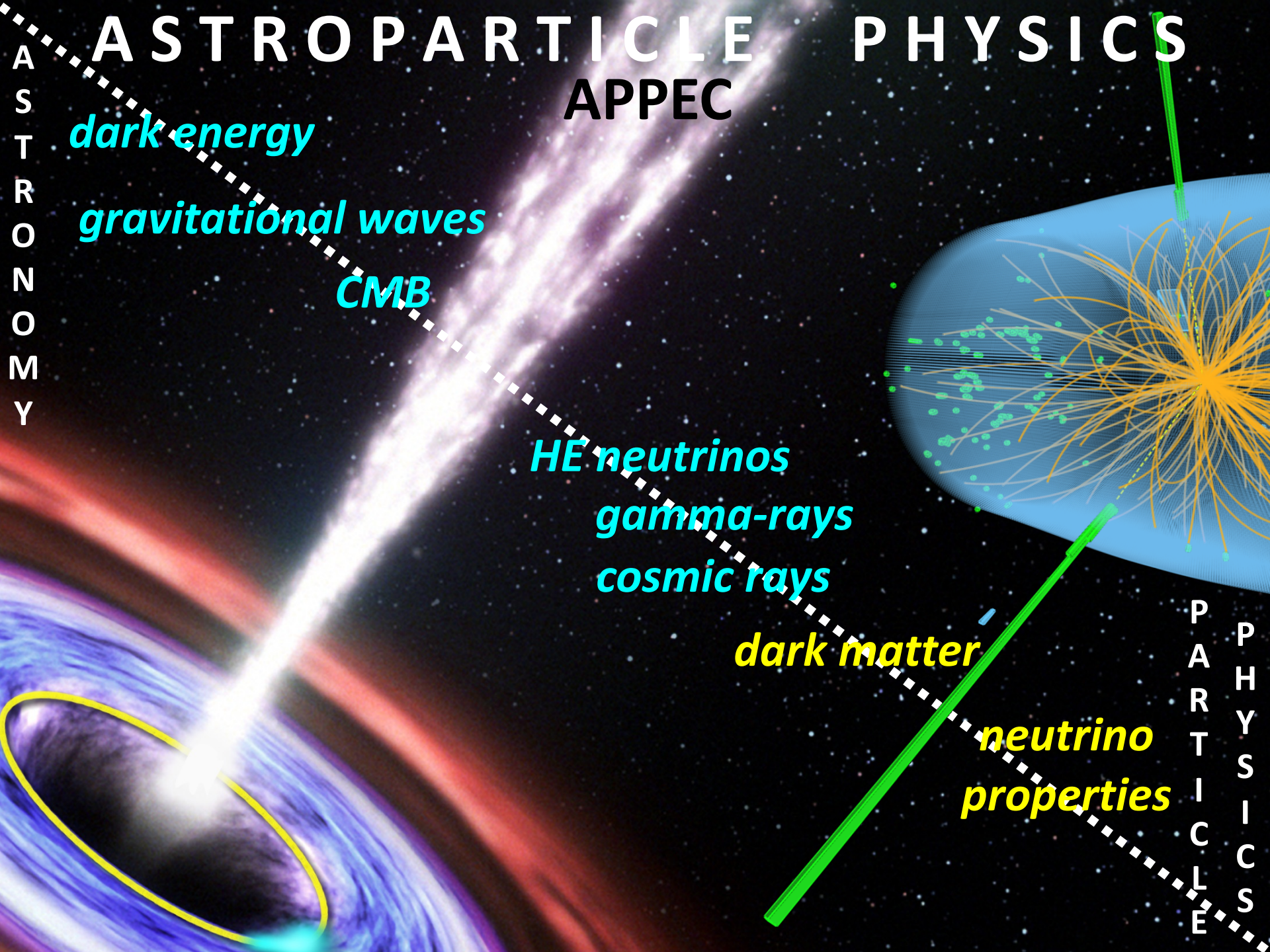
gamma-rays

cosmic rays

dark matter

neutrino properties

PARTICLE PHYSICS



ASTROPARTICLE PHYSICS

APPEC

ASTRONOMY

PARTICLE PHYSICS

2015

dark energy

LVC

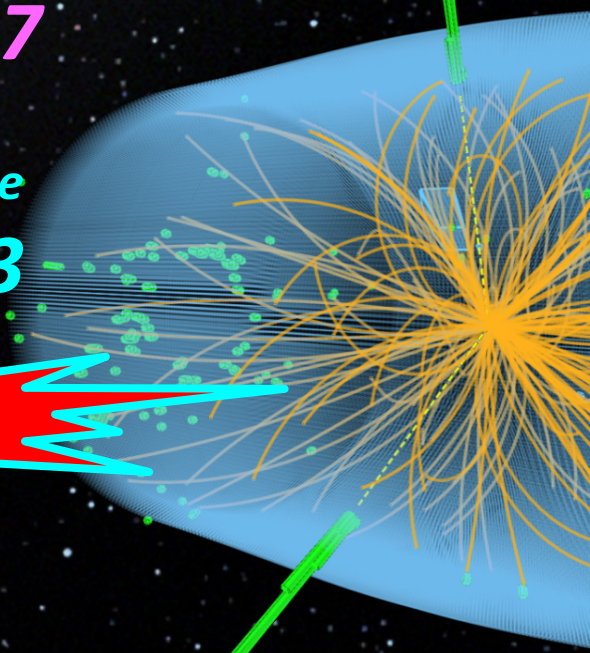
gravitational waves

CMB

2017

IceCube

2013



PeV neutrinos

gamma-rays

cosmic rays

dark matter

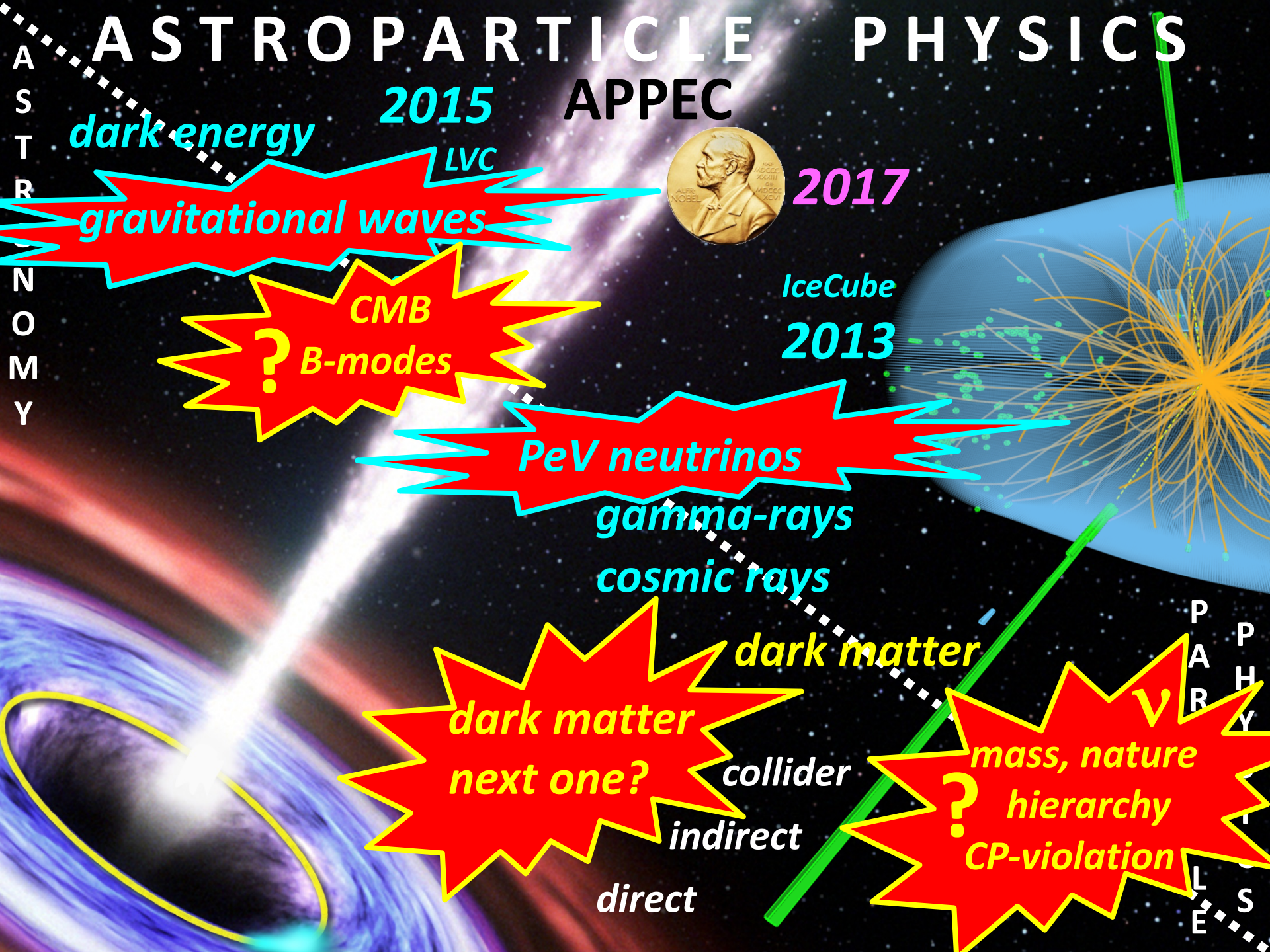
dark matter next one?

collider

indirect

direct

neutrino properties


ASTROPARTICLE PHYSICS
ASTRONOMY
PARTICLE PHYSICS
2015
APPEC
dark energy
LVC
gravitational waves
2017
CMB
?
B-modes
IceCube
2013
PeV neutrinos
gamma-rays
cosmic rays
dark matter
dark matter
next one?
collider
indirect
direct
ν
mass, nature
hierarchy
CP-violation

Gravitational waves – *LVC, ET, LISA*

Interested EU-countries: many

F. LINDE

Adalberto Giazotto left us yesterday
Alain Brillet
I PAPA' di VIRGO

sources!
scrutiny of General Relativity
'standard sirens'

Space: ESA schedule ~ 2030
Ground: timeline in consultation with GWIC

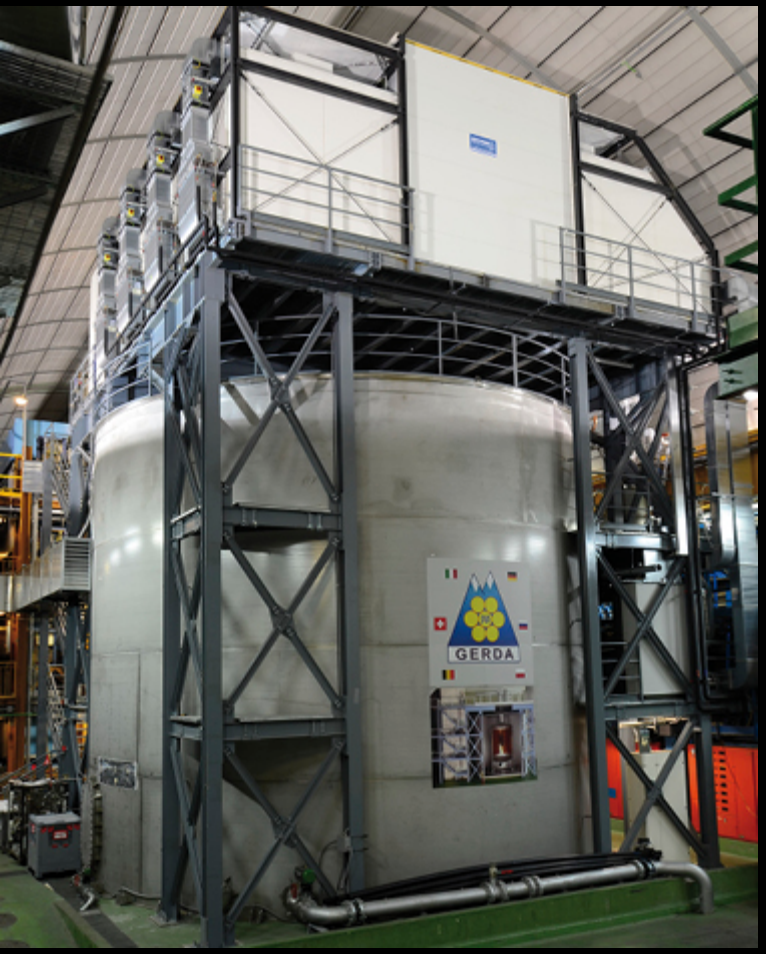
Rare processes – *deep underground labs*

Expansion and new excavations underway

- **SURF**: new excavation for DUNE
  - Excavation begins in 2019 and last 3 yr
- **ARF**: new laboratory in South Korea
  - Ready by mid-end 2019
- **SUPL**: new laboratory in Australia
  - Ready by end of 2018
- **ANDES**: new laboratory Chile-Argentina
  - ready by 2027

Rare processes – *deep underground labs*

0νββ-decay



towards ton-scale experiments

(and also direct ν-mass measurements)

direct Dark Matter interactions

towards 50 (Xe) and 300 (Ar) ton-scale experiments

(and a rich variety of other approaches …)

Challenges for next DM, ββ frontiers; Challenges for LNGS

- Attack and cover the IH region → 1-ton neutrinoless ββ
- WIMPS DM : Reach the neutrino background → n-ton exps. n= 20, 50 ?

Need for GLOBAL COORDINATION

Promising – *bright* – future ahead!

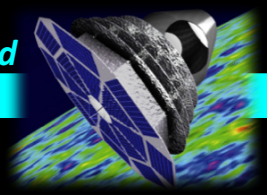
F. LINDE

COSMOLOGY

NEW

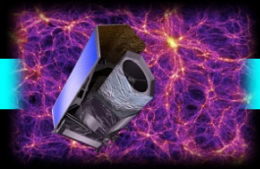
PIXIE
CORE/LiteBIRD

+ ground-based



CMB

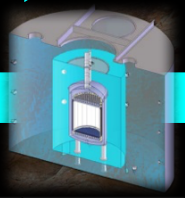
DESI, LSST
Euclid



DE

multi-ton
argon/xenon

+ other technologies



DM

2016 2018 2020 2022 2024 2026 2028 2030 2032 2034

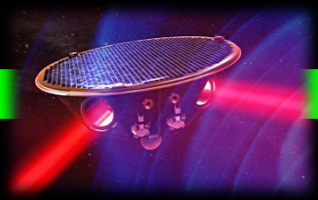
1t 0νββ
JUNO, ...
DUNE/HK

+ direct ν-mass ...

neutrino

ν

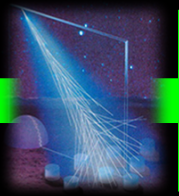
AdvVirgo/LIGO+
ET
LISA



GW

HEU

AugerPrime, TA
CTA
Icecube, KM3NeT, GVD



HE CR-, γ-, ν-observatories

Organisational issues

- European Commission
- European Coordination
- Global collaboration/coordination
- Particle physics & Astronomy
- Inter-disciplinary opportunities

Societal issues

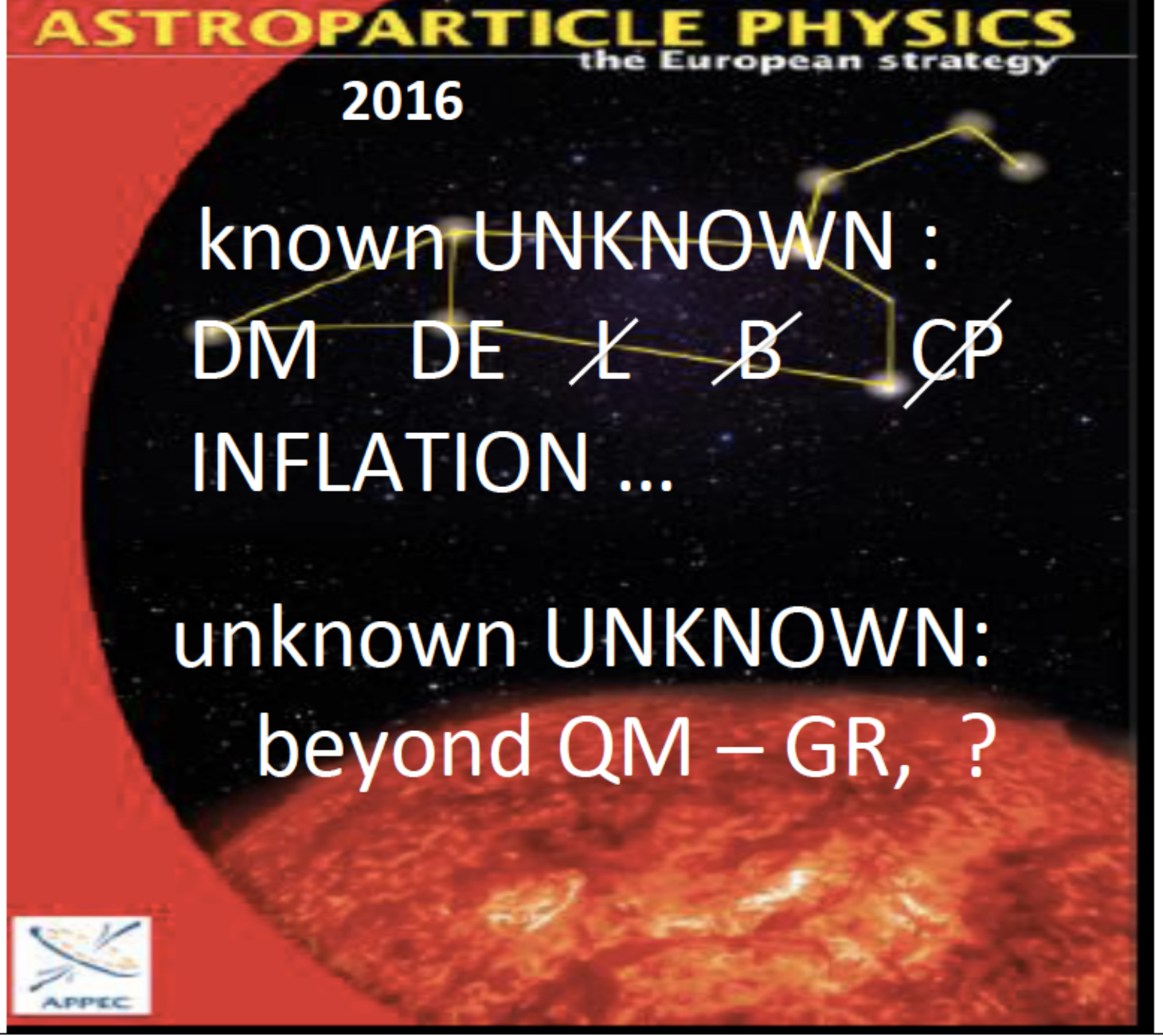
- Gender balance
- Education & Outreach
- Industry

The importance of being **SMALL**

My recommendation: beware the temptation of going ONLY for LARGE enterprises

The protective shield of large, Big Science: too big to fail!

Richness of small, “unorthodox” projects based more on clever ideas than on muscular, managerial strength!


ASTROPARTICLE PHYSICS
the European strategy
2016
known UNKNOWN :
DM DE L B CP
INFLATION …
unknown UNKNOWN:
beyond QM – GR, ?
APPEC

xtraordinary step forward in our
nowledge of the Universe:
t, beware, Nature is rich of "unknown unknown"
after all Physics had already produced a
omprehensive, fundamental theory of all observed
rces of nature" at the end of the XIX century...

aybe the DM and the DE mysteries could
present the XXI century black-body and
notoelectric problems

a final thought …

- **An exciting moment in fundamental physics: we have discovered, validated and (still partially) understood two crucial territories of our knowledge - the SMs of particle physics and cosmology**

- We know that there must exist a **new land** – that of the "physics beyond the SMs" – but we don't know where it is, what shape it may have → hence we've to proceed with **an open mind** and fully **exploiting the synergy of all possible** (and sometime even seemingly **impossible**) **ways to reach it – need for global coordination in our efforts, ex. Global Research Infrastructures**

- **No doubt, ASTROPARTICLE PHYSICS is one of the most extraordinary ways to proceed in this fascinating journey towards the unknown!**

Roadmap event: 9 January 2018

APPEC European Astroparticle Physics Roadmap

APPEC 9 January 2018
Brussels
Europe/Amsterdam timezone

APPEC Launch Event 2017 for the new European Physics Roadmap

For questions please contact: Job de Kleuver
appec@nwo.nl

The Astroparticle Physics European Consortium (APPEC) will proudly present the new European Astroparticle Physics Strategy 2017-2026.

The event will take place on 9 January 2018 in Brussels.

The new APPEC strategy will be presented, addressing scientific issues and an update of the long term scientific strategies. Crucial organisational aspects and societal issues like global collaboration, community building, gender balance, education, public outreach and relations with industry will be discussed. By acting coherently upon these recommendations, Europe will be able to fully exploit the tantalizing discovery potential in Astroparticle Physics.

The ceremony will start with the new strategy, followed by a contribution of Robert Jan Smits, the EC Director General of DG RTD, a keynote talk about the exciting prospects of Gravitational Waves science and more.

The one-day event will include an interactive and lively afternoon programme for scientists, policy makers and representatives of funding agencies discussing the recommendations and how to implement them between all participants. Participants are kindly invited for active contributions and bringing up ideas.

Participation in the APPEC Roadmap event is free of charge.

We are looking forward to seeing you in Brussels.

Starts 9 Jan 2018 10:00
Ends 9 Jan 2018 18:00
Europe/Amsterdam

Brussels
tbd